4128

ADB016792

ADB016792

TARADCOM

LABORATORY

TECHNICAL REPORT

NO. 12222

FINAL REPORT

A FEASIBILITY STUDY OF A NAVIGATIONAL GRID SYSTEM FOR REMOTE CONTROL TARGET VEHICLE APPLICATIONS

20 December 1976

Distribution limited to US Government agencies only; Test and evaluation; other requests for this document must be referred to USA TARADCOM, ATTN: DRDTA-UL.

by Kaman Sciences Corporation
1500 Garden of the Gods Road
Colorado Springs, Colorado
80907

U.S. ARMY TANK-AUTOMOTIVE RESEARCH AND DEVELOPMENT COMMAND
Warren, Michigan 48090

20030617100

~~20020815066~~

[redacted]

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 12222	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A FEASIBILITY STUDY OF A NAVIGATIONAL GRID SYSTEM FOR REMOTE CONTROL TARGET VEHICLE APPLICATIONS		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER K-77-10U(R)
7. AUTHOR(s) John W. Erskine		8. CONTRACT OR GRANT NUMBER(s) DAAE07-76-C-0194
9. PERFORMING ORGANIZATION NAME AND ADDRESS Kaman Sciences Corporation 1500 Garden of the Gods Road Colorado Springs, Colorado 80907		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DA Project Number BA765712MN01
11. CONTROLLING OFFICE NAME AND ADDRESS Systems Development Office (DRDTA-RE) USA TARADCOM Warren, Michigan 48090		12. REPORT DATE 20 December 1976
		13. NUMBER OF PAGES 51
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to US Government agencies only; Test and evaluation; other requests for this document must be referred to USA TARADCOM, ATTN: DRDTA-UL.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Remote Control Target Vehicle
Navigational Grid
Automatic Guidance System

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of the contracted work was to demonstrate the feasibility of a navigational grid system conceived by Kaman Sciences Corporation. The report describes system operation, the field test demonstration, and the analysis of data obtained during the field test.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

KAMAN SCIENCES CORPORATION
1500 Garden of the Gods Road • Telephone (303) 599-1500
Mailing Address: P.O. Box 7463, Colorado Springs, Colo. 80933

A KAMAN COMPANY

FINAL REPORT

A FEASIBILITY STUDY OF A NAVIGATIONAL GRID SYSTEM FOR REMOTE CONTROL TARGET VEHICLE APPLICATIONS

K-77-10U(R) 20 December 1976

TABLE OF CONTENTS

I. INTRODUCTION

The purpose of the contracted work, reported herein, has been to demonstrate the feasibility of a navigational grid as conceived by Kaman Sciences Corporation (KSC). The ultimate goal is to provide a system which will control target vehicles in a manner realistically simulating the behavior of combat vehicles under attack.

As will be described in later sections, the field tests of the navigational grid proved its feasibility. Analysis of data obtained during the field test indicates that the following system accuracies were obtained:

(1) The short term (several hours) repeatability of the system, measured under relatively constant temperature conditions, was .057 meters (1 sigma).

(2) The long term (4 days) repeatability of the system including temperature effects was .53 meters (1 sigma).

(3) The long term repeatability with temperature effects analytically removed was .18 meters (1 sigma).

II. System Description

A. System Concept

The position-determining navigational grid system consists of three fixed-location transmitters and an arbitrary number of mobile receivers utilizing the positional information provided by the transmitters.

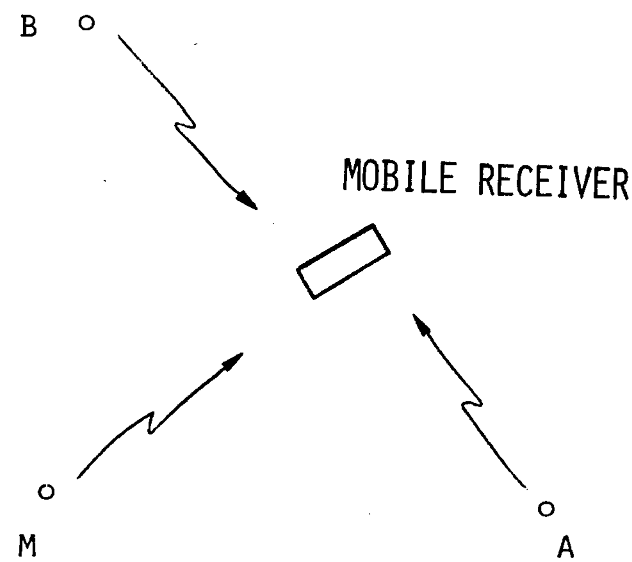
The three transmitters are alternately turned on for specified time intervals and operate at the same frequency with a constant phase relation. A mobile receiver will observe that the received phase differences of the RF pulses vary as a function of position relative to each transmitter pair. These phase differences are detected and can then be used to determine relative position and guidance information. The phase difference is described analytically in Figure 1. Figure 2 shows the idealized grid pattern for three transmitters placed in the corners of a four by six unit test area.

B. Transmitter Sites

Simplified functional block diagrams of the navigational grid transmitters are shown in Figures 3 and 4. The two slave transmitters are electrically identical and differ functionally only in their programmed transmit intervals.

The master transmitter contains a reference oscillator at the prescribed transmit frequency (23.790 Megahertz). The Control Programmer gates this R.F. signal on and off such that the transmitted output is in accordance with the timing diagram shown in Figure 5.

SYSTEM CONCEPT



M, A, B ARE IN PHASE AND TRANSMITTING SEQUENTIALLY.

RECEIVER SEES SIGNALS:

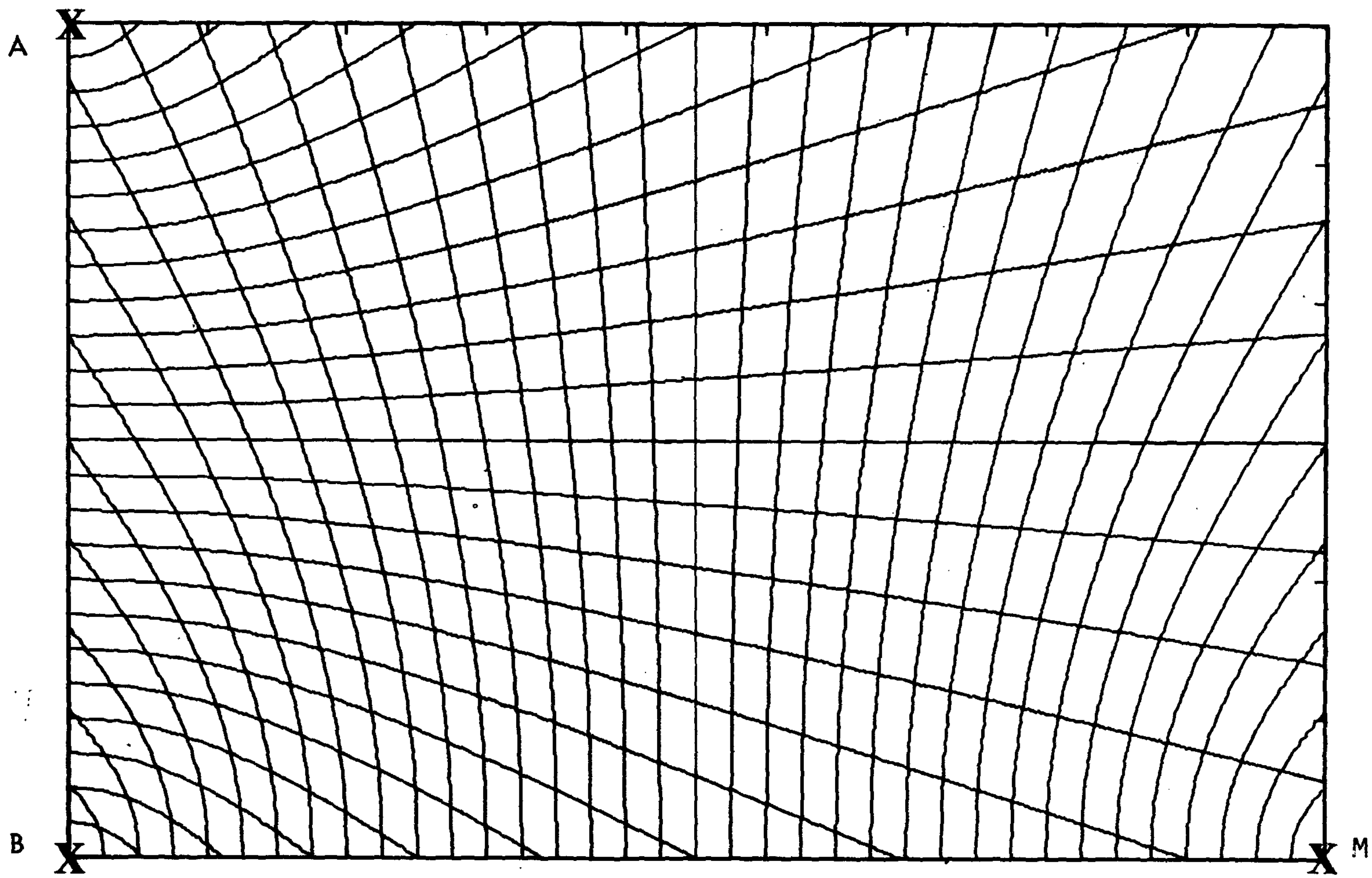
$$S_1 = S_M \sin(W_o t + \phi_M)$$

$$S_2 = S_A \sin(W_o t + \phi_A)$$

$$S_3 = S_B \sin(W_o t + \phi_B)$$

FIGURE 1

ANALYTIC DESCRIPTION OF RECEIVED SIGNALS



NOTES : (1) Transmitters located at points A, B, & M

(2) Grid pattern is for A-B & B-M zero phase differences

(3) A- M zero phase differences are not shown for simplicity

FIGURE 2 IDEALIZED NAVIGATIONAL GRID PATTERN

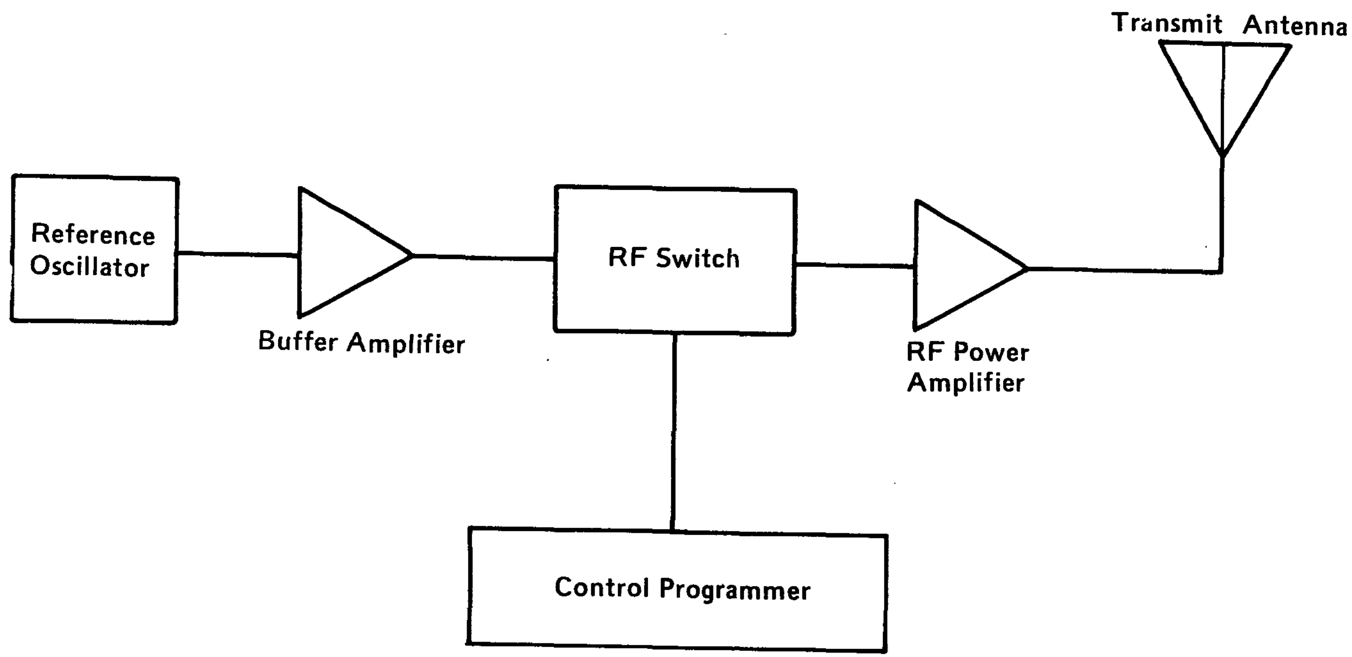


FIGURE 3

MASTER TRANSMITTER BLOCK DIAGRAM

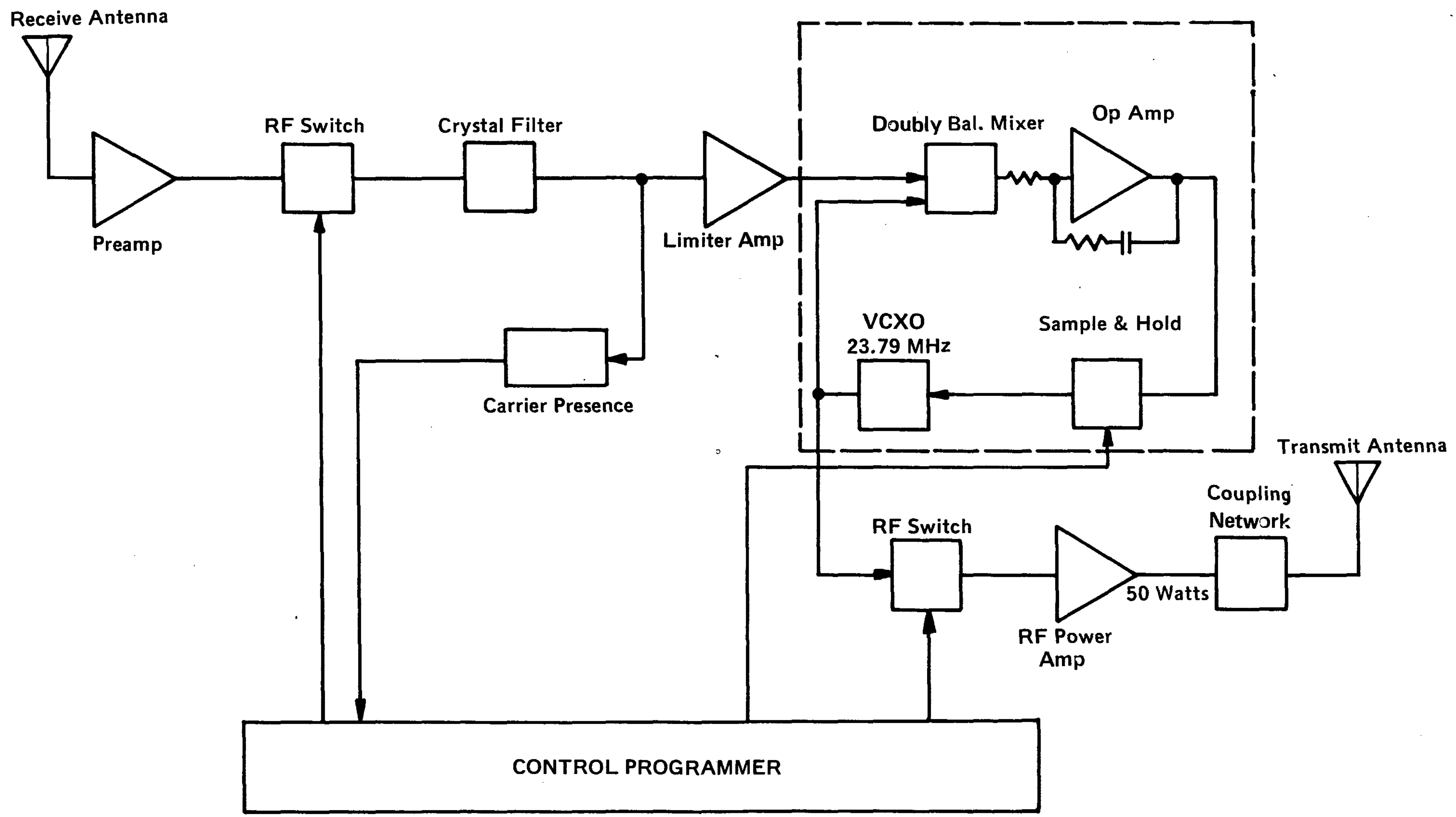


FIGURE 4

SLAVE TRANSMITTER BLOCK DIAGRAM

Each of the slave transmitters contains an R.F. receiver capable of detecting the master and the other slave transmitter pulses. A Phase Stable Oscillator (PSO) is phase locked to the master R.F. pulse when it is received. When the master R.F. pulse is not present, the phase stable oscillator is placed in a 'hold' mode. The output of the PSO thus becomes the phase reference for the slave transmitter. Deviations in phase of the PSO output are corrected each time a master transmit pulse is received.

The control programmer searches for the synch space (shown in Figure 5) such that the timing cycle of the slave transmitter can be synchronized to that of the master transmitter. If slave 'A' detects a master transmitter pulse and then a valid synch space it will phase lock on the master signal and then transmit during its allocated time period. Similarly, when slave 'B' detects master transmitter, valid synch space, and slave 'A' conditions, it will phase lock on the master and transmit during its allocated time period.

The three transmitters now comprise the navigational grid system. Each of the slaves operates with a constant R.F. phase relative to the master and is sequentially time modulated in the prescribed manner.

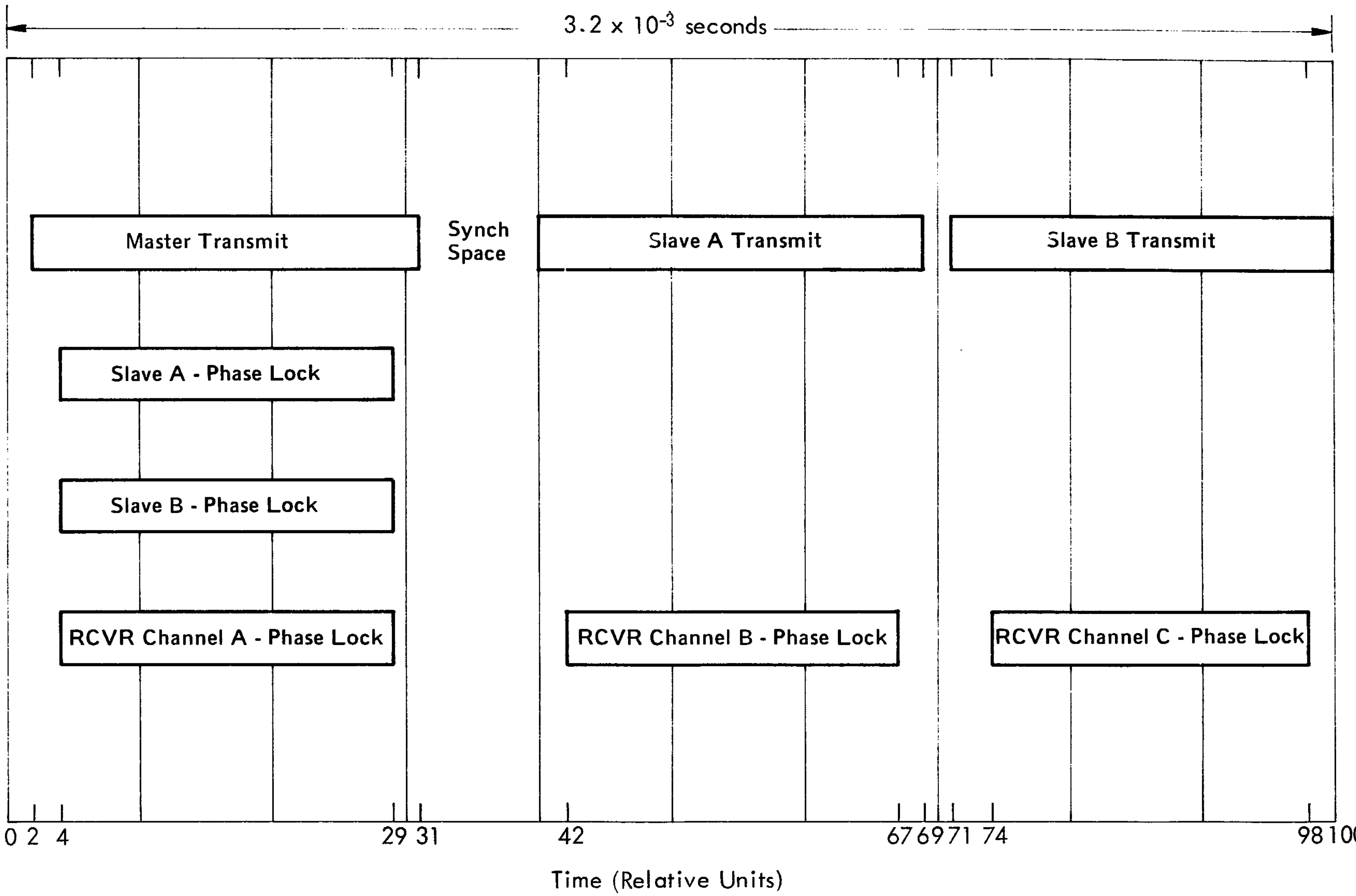


FIGURE 5

SYSTEM TIMING DIAGRAM

C. Receiver

A simplified functional block diagram of the navigational grid receiver is shown in Figure 6. The R.F. circuitry of the receiver is virtually identical to that of the slave transmitters except that the control programmer splits the received signal into three channels corresponding to the three transmitters. A PSO phase locks on each of the transmitted pulses such that the PSO outputs are related as follows (see Figure 1 also):

$$E_1 = \sin\ (2\pi f_o t + \phi_M)$$

$$E_2 = \sin\ (2\pi f_o t + \phi_A)$$

$$E_3 = \sin\ (2\pi f_o t + \phi_B)$$

where f_o = transmit frequency

t = time

$\phi_M = \frac{d_M}{\lambda}$ = phase shift due to distance between the master transmitter and the receiver

d_M = distance between master transmitter and receiver

λ = wavelength at transmit frequency

ϕ_A = phase shift (as above) due to distance between the slave 'A" transmitter and the receiver

ϕ_B = phase shift (as above) due to distance between the slave 'B' transmitter and the receiver

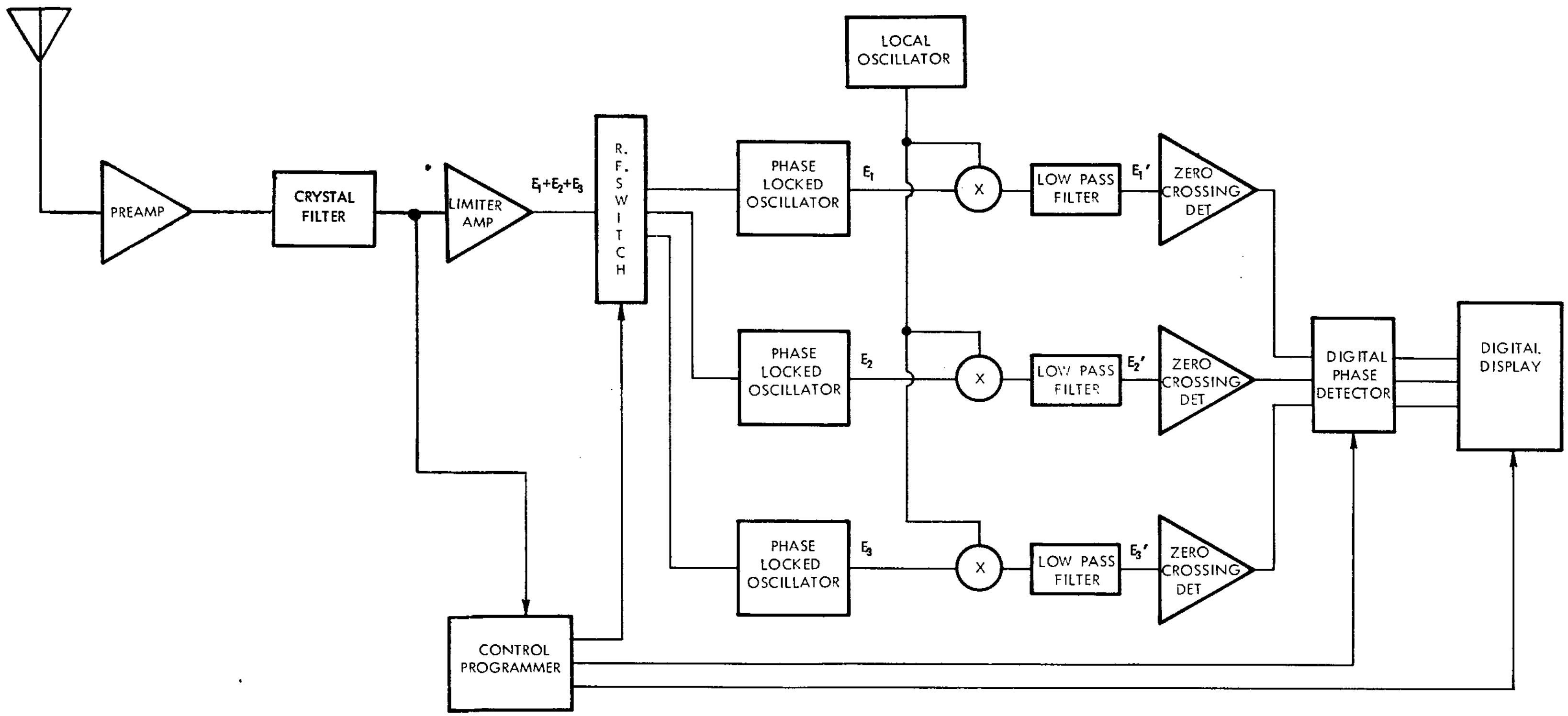


FIGURE 6

NAVIGATIONAL GRID RECEIVER FOR RCTV SIMPLIFIED FUNCTIONAL BLOCK DIAGRAM

Each of the PSO outputs is mixed with a local oscillator ($f = f_o$-20 Khz) and filtered to remove the higher sideband. The resulting signals have the following form:

$$E_1' = \sin\ (4\pi t \times 10^4 + \phi_M)$$

$$E_2' = \sin\ (4\pi t \times 10^4 + \phi_A)$$

$$E_3' = \sin\ (4\pi t \times 10^4 + \phi_B)$$

It should be noted that these signals have been translated in frequency from 23.790 megahertz to 20 kilohertz but still retain the same phase relationships as the original received signals. This allows the relative phase measurement to be accomplished at a frequency where standard techniques may be employed.

The relative phase differences between the translated signals are determined digitally by counting the time difference between the positive zero crossings of the translated signals. The results are displayed on the receiver front panel Liquid Crystal Displays (LCDs) and outputed via ribbon cable to a microcomputer system for further processing and recording.

The idealized grid pattern shown in Figure 2 is a plot of those points for which the quantities $\phi_A - \phi_B$ or $\phi_B - \phi_M$ equal integer multiples of 2π radians (360 degrees). Each of the lines described by this criteria is defined as a zero phase crossing for the corresponding transmitter pair. The number of these zero phase crossings, from some arbitrary starting point, is also displayed on the receiver front panel LCDs. If the receiver is moved on the straight line between a pair of transmitters a distance equal to one-half wavelength, then the received phase from one transmitter will increase by π radians (180 degrees) while the received phase from the other

transmitter will decrease by π radians (180 degrees). The relative phase difference has thus changed by 2π radians (360 degrees) for a change in position of one-half wavelength (6.3 meters).

III. Field Test

A. Tests Performed

A field test of the KSC navigational system was required to adequately evaluate the system accuracy and repeatability and to resolve potential problems such as line of sight limitations and multipath reception from the terrain or large objects.

A field test site which included a wide variety of terrain conditions such as dry washes, rolling wooded hills, and open meadows was selected at Fort Carson, Colorado. The three navigational grid transmitters were set up to approximate a 4 km x 6 km area as indicated on the map of the test site area shown in Figure 7. An arbitrary path which included 42 check points was chosen by U.S. Army technical representatives. The transmitter sites and a number of these checkpoints were surveyed in order to provide absolute references for future data analyses.

The mobile receiver was mounted in a M577 Armored Command Post which was manually guided to each of the checkpoints. Relative phase information was obtained at each checkpoint along the path for at least 12 traversings of the path. Photographs of the transmitter sites and the receiver set up are shown in Appendix A.

The raw data obtained during the field tests, conducted 8 thru 19 November 1976, are reproduced in Appendix B. Analyses performed on the data are described in the next section. Specific explanations for each of the tests are given as follows:

(1) Test Date - 11 November 1976

Data obtained on this date were obtained under light snow/cold (25°F) weather conditions. In order to provide

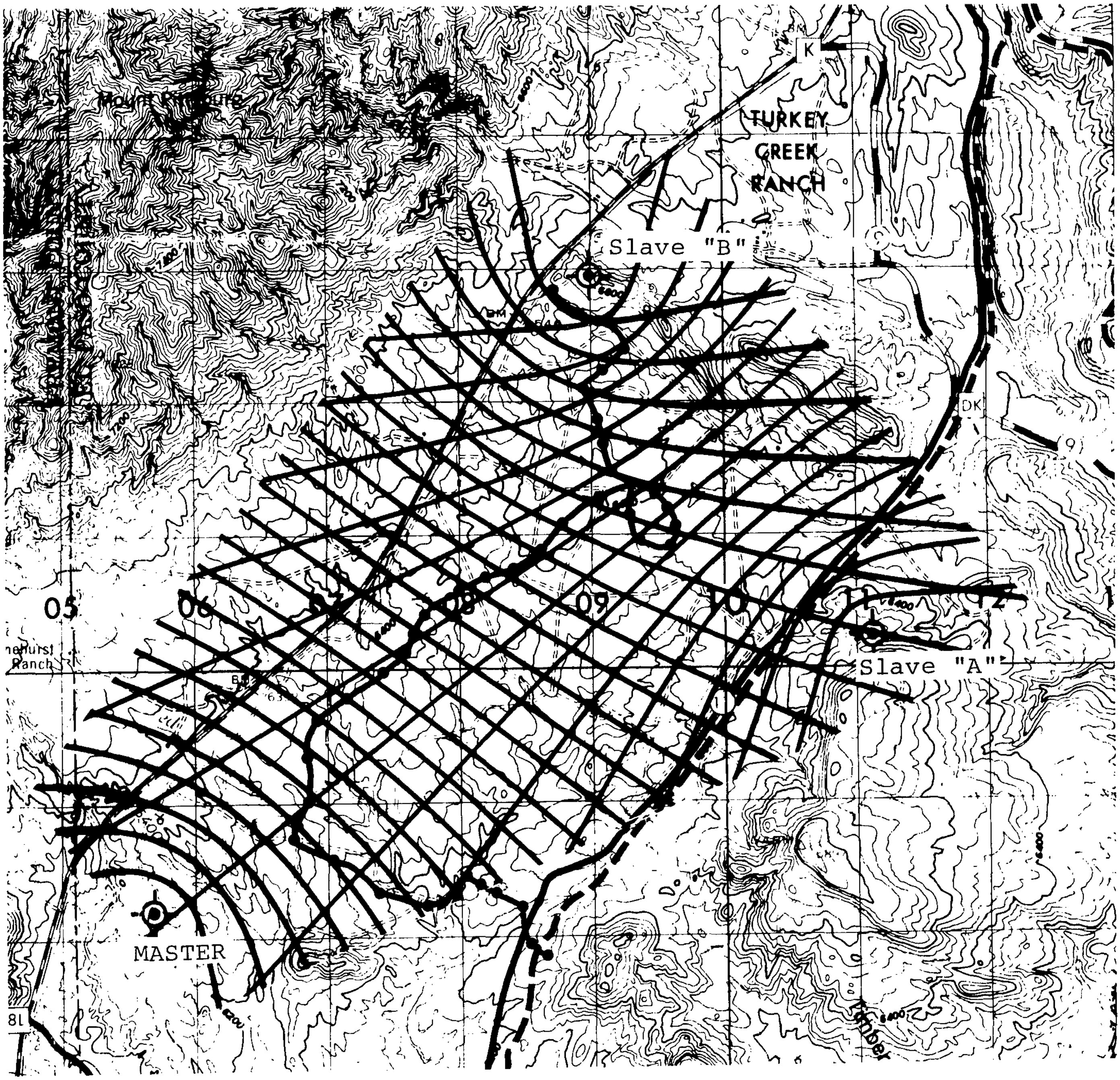


FIGURE 7

MAP OF TEST SITE AREA WITH GRID
AND PATH OF CHECKPOINTS SUPERIMPOSED

repeatability data, the course was reduced to ten check points in length. This truncated path was traversed three times in a period of approximately three hours. These data provide the basis for the short term/constant temperature repeatability calculation.

(2) Test Dates - 15 and 16 November 1976

Data from these dates are for a night/day operation conducted in order to evaluate any significant changes in R.F. propagation characteristics. A total of six traverses were made of the complete forty-two checkpoint path starting at approximately 2200 hours on 15 November 1976 and concluding at approximately 1515 hours on 16 November. The conclusion drawn from this data is that diurnal propagation characteristic changes are not significant.

(3) Test Date - 17 November 1976

Traverses of the complete forty-two checkpoint path continued. Three traverses were accomplished starting at approximately 1100 hours and concluding at approximately 1530 hours. The additional data appearing on the raw data form under the columns 6A, 7A, 8A, etc. was an attempt to correlate observed delta phase shifts with distance. After the primary data was recorded for a particular checkpoint, the receiver vehicle was moved approximately one meter forward and another set of phase readings was recorded. Noting that the change in phase is a function of the direction traveled, one can conclude that one meter corresponds to between 50 and 60 degrees along the entire path if measured in the direction of maximum sensitivity.

(4) Test Date - 18 November 1976

Three additional traverses of the complete path were accomplished starting at approximately 1030 hours and concluding at approximately 1400 hours.

In addition to the normal traverses of the path, data were obtained and recorded on magnetic tape, in a manner consistent with a vehicle control operation, while the vehicle was in motion. A four checkpoint segment of the path was recorded a number of times to enable repeatability analyses to be performed. A twenty checkpoint segment of the path was recorded to provide "typical" data. These data have been recovered from tape and a hard copy printout produced. A typical printout of the data recorded between two checkpoints (#34 and #35) is reproduced as Appendix C. Examination of this data shows the expected phase changes and zero crossings as the vehicle traversed the path. An erroneous zero count is also noted in the B channel data where the count increased from 5118 to 5120 (see Section III.B for details). Thorough analysis of this data is beyond the scope of the present effort and will be accomplished in the future.

(5) Effects of nearby vehicles

The effect of having another vehicle in close proximity to the receiver was evaluated at four checkpoints. Baseline data was recorded and the second vehicle gradually moved closer. As discussed later, the effects are small for reasonable separation distances.

III. B. Problems Encountered

As with any development program, problems were encountered with portions of the hardware. These problems were anticipated and a successful demonstration was obtained.

The problems encountered were a result of jitter in the phase of the 20 Khz I.F. signals. This jitter resulted in large variations (typically 20 degrees) in the displayed phases due to the digital technique employed to calculate the phase. In addition, this jitter caused the zero crossing counters to drift occasionally.

The phase jitter has two primary causes. The first is the accumulated phase errors of the phase stable oscillators when in the "hold" mode. These phase errors are reduced to zero each time the PSO is placed in the "sample" mode (see Sections II.B and II.C). The more significant cause, however, appears to be short term phase noise between the reference oscillator of the master transmitter and the local oscillator contained in the receiver. A potential solution to this problem is to specify a more stable oscillator for these applications.

If viewed on an oscilloscope, the jitter in the phase of the 20 Khz I.F. signals appears to be random. This would indicate that some form of integrating phase determination technique would also correct the problem. In fact, a form of integration was used during the field test. In addition to the front panel display, the phase information was outputed to a MicroComputer System (MCS). The MCS averaged 32 consecutive samples and displayed the result on a CRT terminal. This process continued until the CRT terminal was displaying 32 averages. The MCS then calculated the average value of the previous 32 averages

and displayed the result on the CRT. These final averaged values were average values over .512 seconds of real time data and were the values recorded manually during the field test. The first average was recorded on tape during the moving vehicle testing.

IV. Data Analysis

A. Definition of Terms

As described in the previous section the relative phase difference between transmitters was recorded each time a check point was visited. "A" channel data was defined as the relative phase difference between the master and "A" slave transmitters ($\phi_A - \phi_M$). "B" channel data was defined as the relative phase difference between the master and "B" slave transmitters ($\phi_M - \phi_B$). Each sample point therefore generates two data points. For analytical purposes, it is convenient to view the raw phase data as a pair of arrays.

$$A_{ij} \text{ and } B_{ij}$$

where

$$i = \text{checkpoint number } (1 \leq i \leq 42)$$

and $j = \text{traverse or run number } (1 \leq j \leq 12)$.

The data for 11 November will be considered separately as

$$A'_{ij} \text{ and } B'_{ij}$$

where

$$i = \text{checkpoint number } (1 \leq i \leq 10)$$

and $j = \text{traverse or run number } (1 \leq j \leq 3)$.

Before continuing, it is appropriate to define a mean value and standard deviation. Consider a set of N numbers X_i. The mean value and standard deviation are then defined as:

$$M \equiv \frac{1}{N} \sum_{i=1}^{N} X_i = \text{mean value}$$

and $$\sigma \equiv \frac{1}{N-1} \left[\sum_{i=1}^{N} X_i^2 - \frac{1}{N} \left(\sum_{i=1}^{N} X_i \right)^2 \right] = \text{standard deviation (1 sigma)}$$

B. Short Term Repeatability

If the navigational grid system were perfect, the entries within each row of the data arrays would be identical. The values of the various rows correspond to the phase at the various checkpoints and hence are different. Since the grid system is not perfect and we wish to determine a probable error, the following procedure is used:

(1) Determine a mean value for each row of the arrays.

(2) Construct an array of error terms by subtracting from each entry of the data arrays the corresponding mean value.

(3) Calculate the standard deviation of the error terms.

If it is assumed that the data have a normal distribution, then 68% of the data will be within one standard deviation of the mean value.

The raw data used to calculate the short term repeatability was acquired on 11 November 1976. For this data the temperature was almost constant at approximately 25°F with no sun. Additionally, the course was shortened to ten points such that three traversals of the course could be made within approximately three hours. The standard deviation, calculated as described above, using this data is 2.83 degrees (less than .057 meters). A summary of this calculation is given in Table IV.1.

C. Long Term Repeatability

The long term repeatability calculation is based on the data obtained on 15, 16, 17, and 18 November 1976. These data therefore include turn on/off, temperature, and propagation effects. The standard deviation, calculated as described above, using this data is 26.13 degrees (less than .523 meters). A summary of this calculation is given in Table IV.1.

D. Long Term Repeatability (less temperature)

It was known, from component characterization, that several component devices in the electronics had definite temperature sensitivities. Although temperature control of these devices would solve this problem, no attempt was made to compensate these sensitivities for this field test. It was obvious that the field test data was affected by the ambient temperature changes to which the transmitter and receiver electronics were subjected. This section attempts to evaluate the effects of temperature and to remove them from the repeatability calculation.

Temperature data at the test site was not available. Instead, National Weather Service temperatures recorded at Peterson Field were assumed as valid. It should be noted that Peterson Field is located approximately 20 miles north-northeast of the Fort Carson test site area.

We first assume a second order temperature dependence. Thus each element of our data arrays will be related to temperature as

$$A_{ij} = a_i + bT_{ij} + cT_{ij}^2$$

and

B_{ij} = similar, where T_{ij} = temperature at time of data measurement

and, a_i, b, and c are constants to be determined.

Considering first the A_{ij} data array, we can define an error term, Q, that is the sum of the squares of the differences between the actual data A_{ij} and the predicted value $a_i + bT_{ij} + cT_{ij}^2$.

$$Q = \sum_j (A_{1j} - a_1 - bT_{1j} - cT_{1j}^2)^2$$

$$+ \sum_j (A_{2J} - a_2 - bT_{2j} - cT_{2j}^2)^2$$

$$\vdots$$

Equation 1

$$+ \sum_j (A_{Nj} - a_N - bT_{Nj} - cT_{2j}^2)^2$$

$$= \sum_i \sum_j (A_{ij} - a_i - bT_{ij} - cT_{ij}^2)^2$$

We now wish to determine the coefficients a_i, b, and c such that the error term Q is minimized. In order for Q to be a minimum, the partial derivatives of Q with respect to the coefficients must go to zero.

Equation 2

$$\frac{\partial Q}{\partial a_i} = \sum_j (-2)\ (A_{ij} - a_i - bT_{ij} - cT_{ij}^{\,2}) \equiv 0$$

Equation 3

$$\frac{\partial Q}{\partial b} = \sum_i \sum_j T_{ij}\ (A_{ij} - a_i - bT_{ij} - cT_{ij}^{\,2}) \equiv 0$$

Equation 4

$$\frac{\partial Q}{\partial c} = \sum_i \sum_j T_{ij}^{\,2}\ (A_{ij} - a_i - bT_{ij} - cT_{ij}^{\,2}) \equiv 0$$

From Equation 2 we can obtain

$$a_i = \frac{1}{N_i} \sum_{j=1}^{N_i} A_{ij} - b \sum_{j=1}^{N_i} T_{ij} - c \sum_{j=1}^{N_i} T_{ij}^{\,2}$$

Equation 5

$$= \overline{A_i} - b\overline{T_i} - \overline{cT_i^{\,2}}$$

where $\overline{A_i}$ is defined as the average value of A_{ij}.

Substituting the above into Equations 3 and 4 we obtain

$$\sum_i \sum_j \left[(A_{ij} - \bar{A}_i) + b(\overline{T_i} - T_{ij}) + c(\overline{T_i^2} - T_{ij}{}^2) \right] T_{ij} = 0$$

and
$$\sum_i \sum_j \left[(A_{ij} - \bar{A}_i) + b(\overline{T_i} - T_{ij}) + c(\overline{T_i^2} - T_{ij}{}^2) \right] T_{ij}{}^2 = 0.$$

Note that all the terms in the two equations above are known values except b and c. If the summations indicated are performed, a set of equations result of the form

$$X_1 + X_2 b + X_3 c = 0$$

and

$$X_4 + X_5 b + X_6 c = 0$$

where

$X_1, X_2, \ldots X_6$ are constants.

This set of equations is readily solved for b and c. The values of b and c are then used in Equation 5 to determine the values of a_i.

Utilizing the above procedure, the coefficients for the A_{ij} and B_{ij} data arrays are as follows:

	A_{ij}	B_{ij}
b	2.495	-1.247
c	- .013	- .007

We can now compute a standard deviation which does not include temperature effects. The same procedure is used as previously described except that a predicted (from knowledge of the temperature) value is used instead of the mean value. The standard deviation computed in this manner is 9.22 degrees (less than .184 meters). See Table IV.1 for a comparison of repeatability values.

TABLE IV.1

SUMMARY OF REPEATABILITY ANALYSES

Analysis Description	Number of Data Samples	σ* (meters)	CEP** (meters)
Short Term-Constant Temperature	51	.057	.048
Long Term-Varying Temperature	889	.523	.445
Long Term-Temperature Effects Removed	889	.184	.156

*68% Probability
**50% Probability
Assumes a normal distribution

IV. E. Effect of Nearby Vehicles

The effect of nearby vehicles on received phase shift is highly dependent on the distance between vehicles and the relative position of the vehicles and the transmitter antennas. In Figure 8, we have plotted the worst case modulus of errors introduced by a nearby vehicle as a function of the distance between the vehicles. The data, from which Figure 8 was derived, was obtained at four different checkpoints.

V. Conclusions

Minor problems were encountered with the electronic hardware that warrant a closer look in the future to determine the best means of correction. These problems were circumvented during the system field test via software processing of the data.

The system field test and consequent data analysis confirm the feasibility of this short range navigation system. The system does meet or exceed all specified performance goals. The system does

1) Operate in HF or VHF band.

2) Use less than 50 watts radiated power

3) Use time-shared transmissions.

4) Cover a four by six kilometer area.

5) Relocate an arbitrary point with a CEP of 0.5 meter.

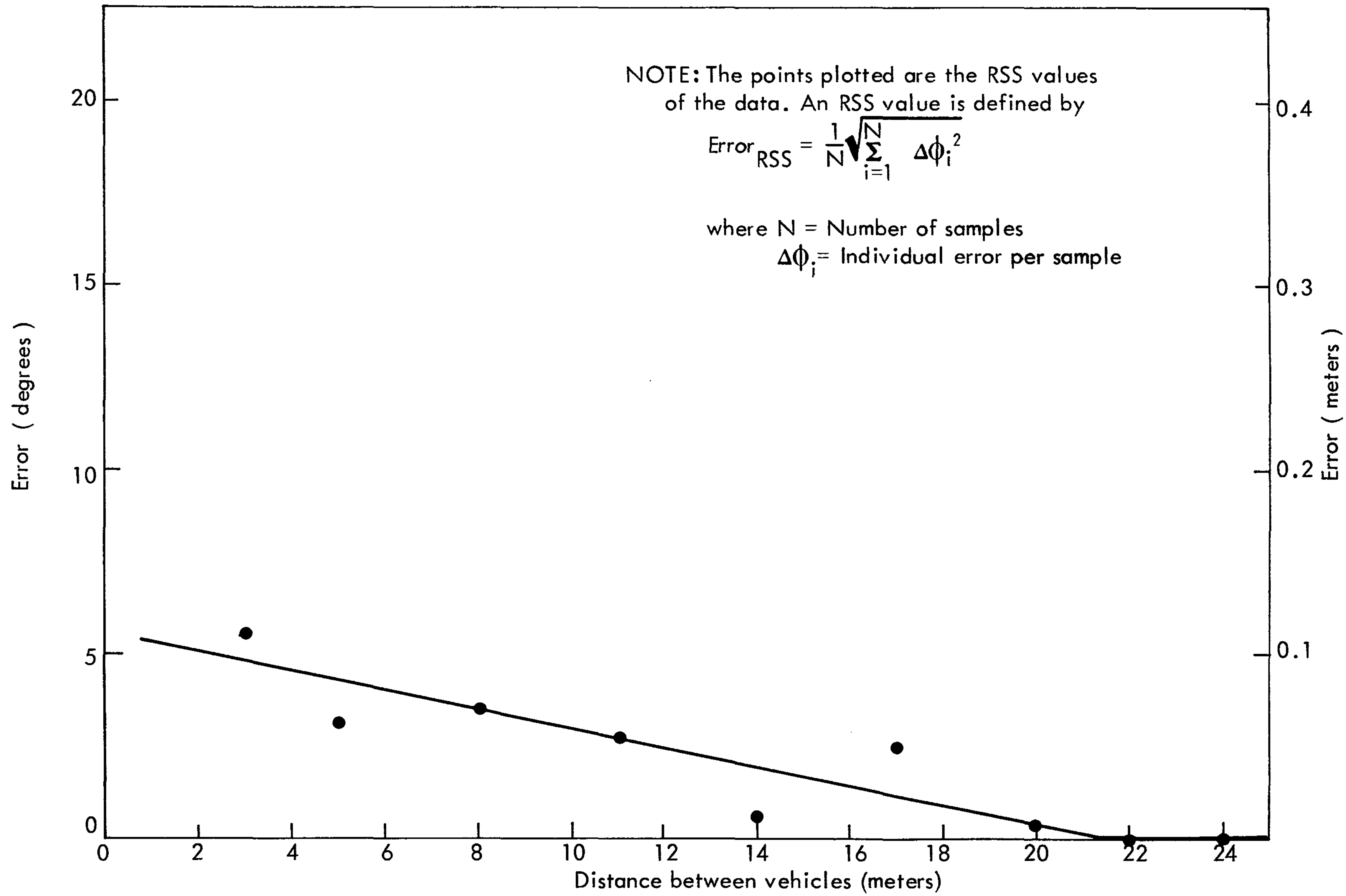


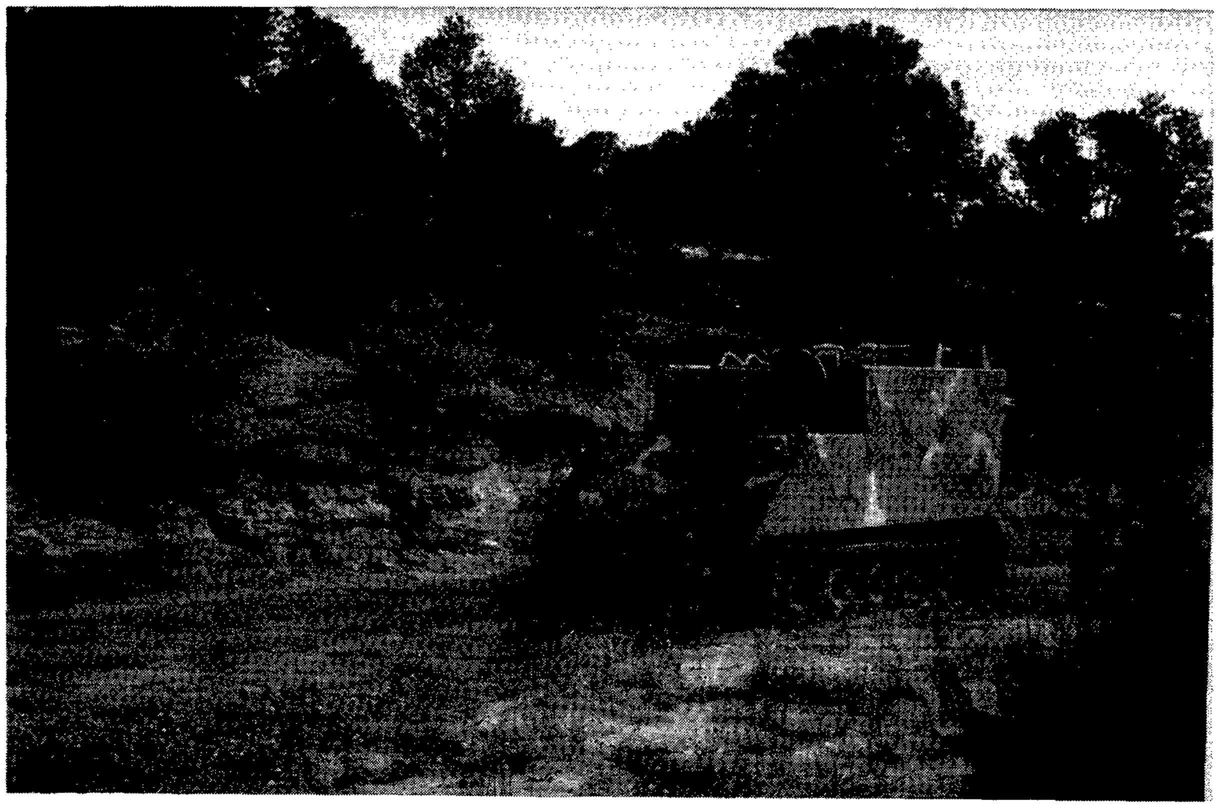
FIGURE 8

ERRORS (RSS) FROM NEAR BY VEHICLES

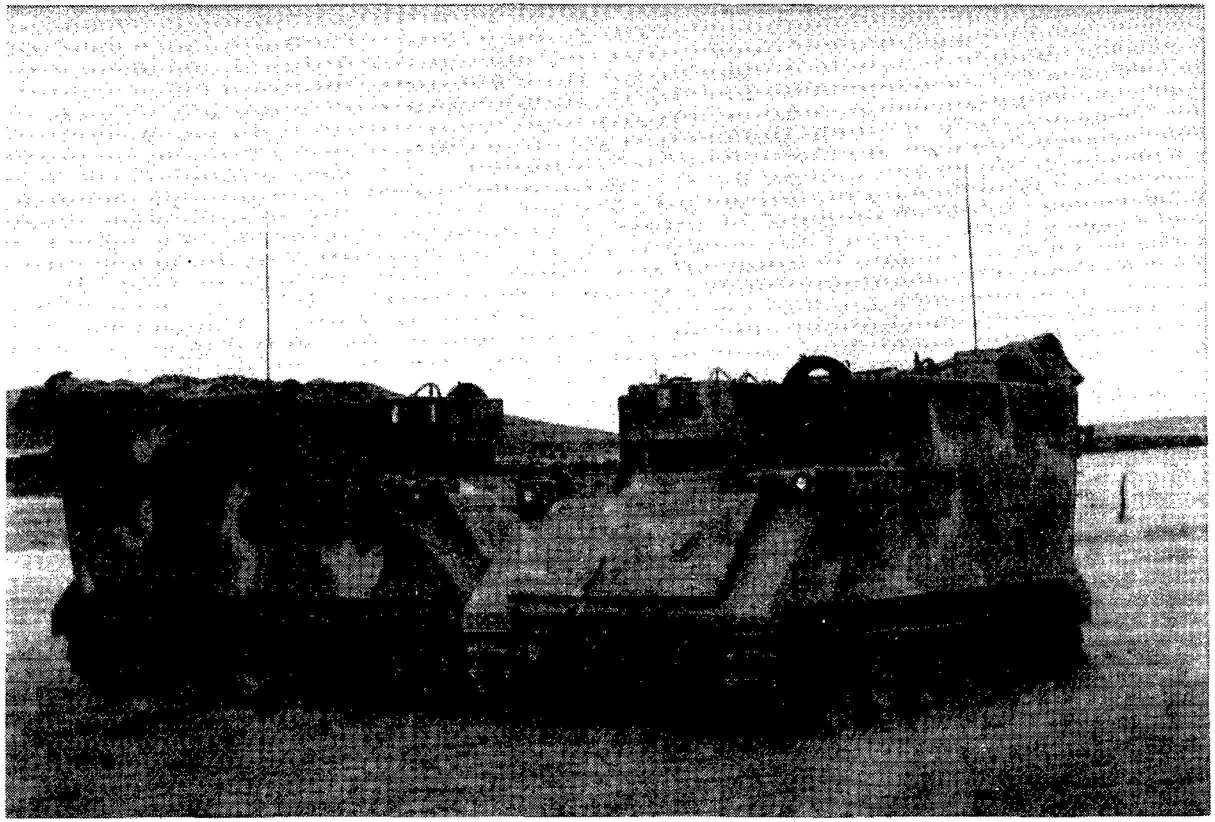
APPENDIX A

FIELD TEST PHOTOGRAPHS

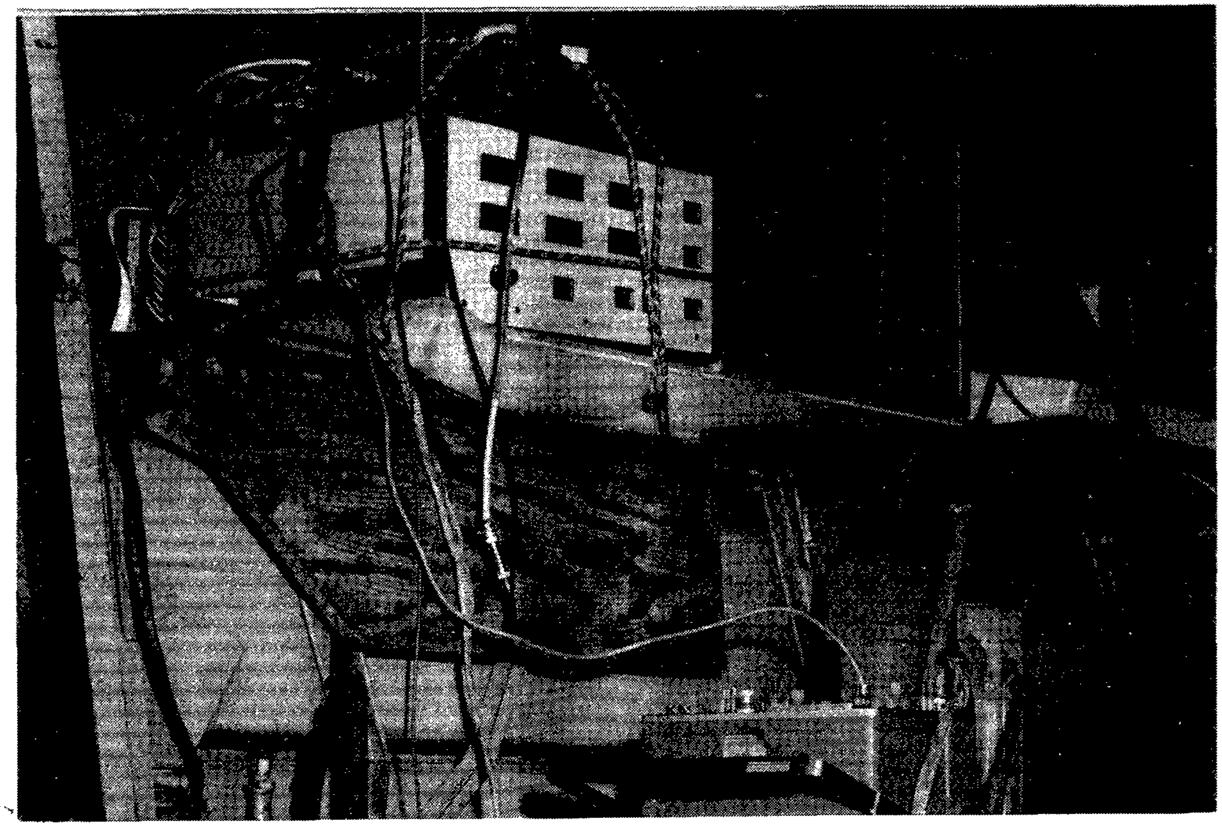
M577 ARMORED COMMAND POST TRAVERSING FIELD TEST AREA
(U.S. Army Photograph)



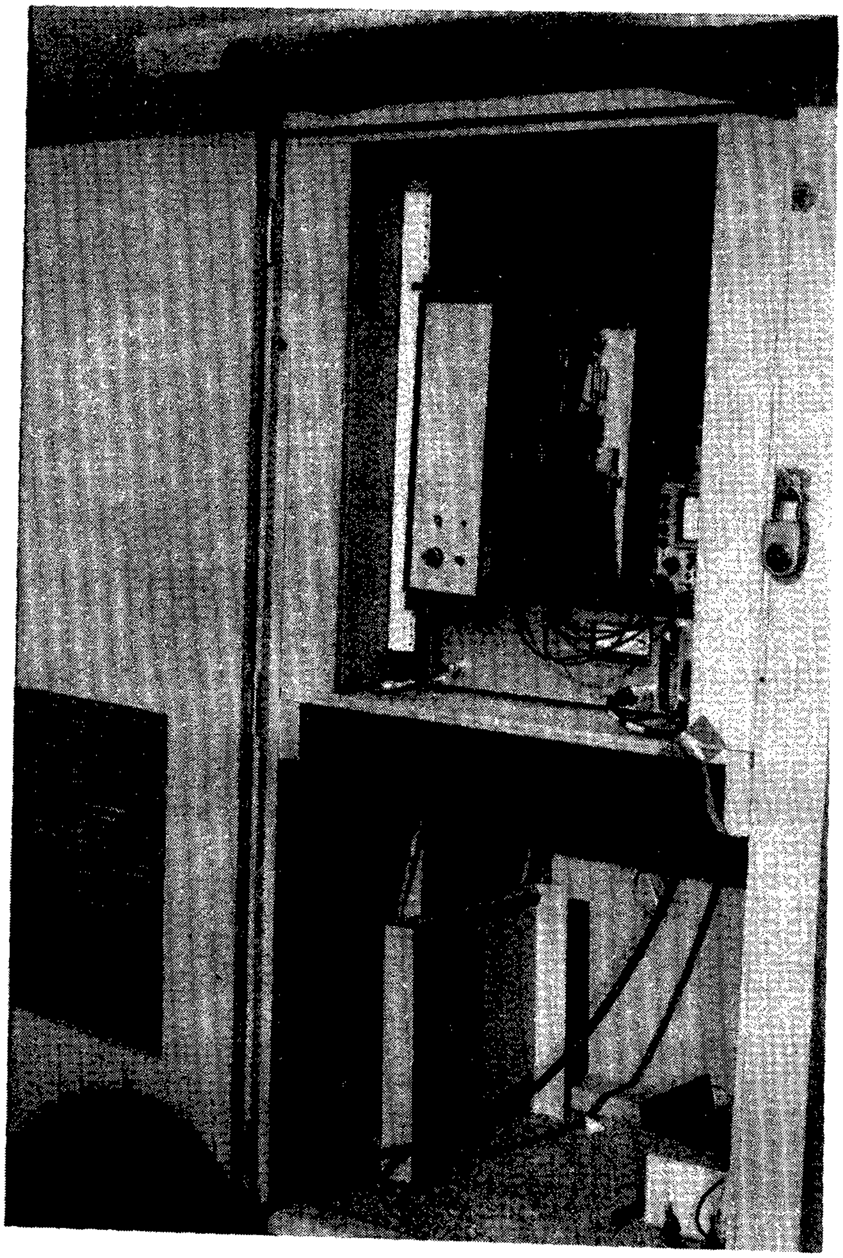
M577 ARMORED COMMAND POST TRAVERSING FIELD TEST AREA
(U.S. Army Photograph)



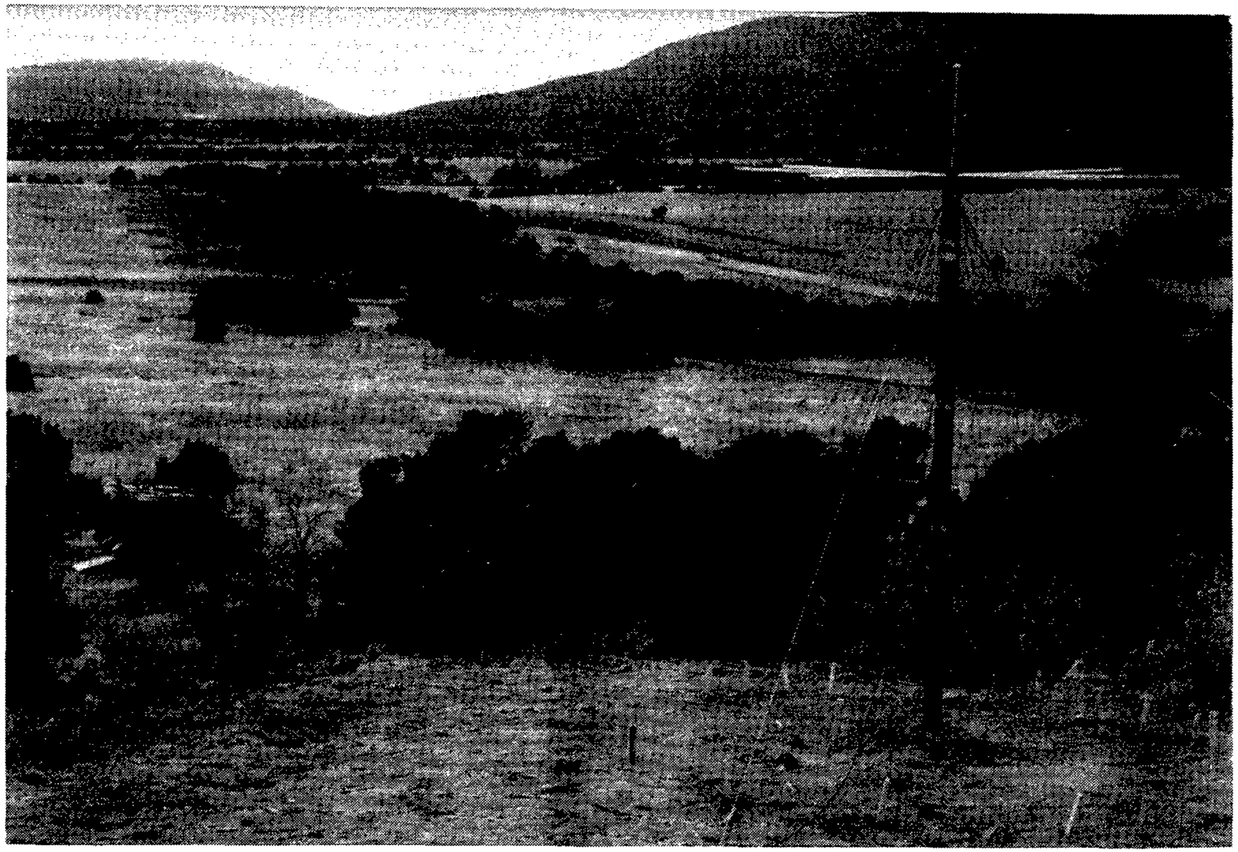
M577 ARMORED COMMAND POSTS POSITIONED FOR "NEAR-BY" VEHICLE TESTS
(U.S. Army Photograph)



RECEIVER ELECTRONICS STRAPPED DOWN INSIDE M577 ARMORED COMMAND POST
(U.S. Army Photograph)



SLAVE "B" TRANSMITTER SHACK DURING INITIAL
CHECKOUT OF NAVIGATIONAL AND SYSTEM CHECKOUT
(U.S. Army Photograph)



SLAVE "B" TRANSMIT ANTENNA OVERLOOKING SMALL PORTION
OF THE FIELD TEST AREA
(U.S. Army Photograph)

APPENDIX B

FIELD TEST RAW DATA

PT	RUN	DAY	TIME	A	B
1	21	11	0	251.	104.
1	22	11	0	251.	103.
1	23	11	0	259.	96.
2	21	11	0	173.	91.
2	22	11	1421	173.	91.
2	23	11	0	165.	95.
3	21	11	0	268.	XXX
3	22	11	0	277.	XXX
3	23	11	0	268.	XXX
4	21	11	0	99.	XXX
4	22	11	0	95.	XXX
4	23	11	0	91.	XXX
5	21	11	0	287.	97.
5	22	11	0	288.	90.
5	23	11	0	285.	94.
6	21	11	0	17.	177.
6	22	11	0	9.	180.
6	23	11	0	17.	177.
7	21	11	1253	154.	273.
7	22	11	1430	155.	273.
7	23	11	0	156.	274.
8	21	11	0	77.	279.
8	22	11	0	69.	288.
8	23	11	0	75.	287.
9	21	11	0	336.	XXX
9	22	11	0	333.	XXX
9	23	11	0	336.	XXX
10	21	11	0	33.	70.
10	22	11	0	37.	72.
10	23	11	0	34.	72.

PT	RUN	DAY	TIME	TEMP	A	B
1	1	15	2209	24.8	237.	103.
1	2	16	158	26.9	245.	94.
1	3	16	450	33.9	237.	102.
1	4	16	818	32.7	245.	98.
1	5	16	1009	35.5	250.	82.
1	6	16	1328	41.9	256.	75.
1	7	17	1100	57.0	254.	74.
1	8	17	1322	61.0	280.	36.
1	9	17	1540	60.9	283.	37.
1	10	18	1035	65.3	272.	56.
1	11	18	1231	67.9	290.	23.
1	12	18	1415	60.2	294.	21.
2	1	15	2211	24.7	142.	96.
2	2	16	200	27.0	142.	92.
2	3	16	453	34.0	151.	87.
2	4	16	820	32.8	161.	83.
2	5	16	1011	35.6	175.	65.
2	6	16	1330	41.9	173.	52.
2	7	17	1102	57.1	167.	64.
2	8	17	1324	61.0	193.	27.
2	9	17	1545	60.7	199.	22.
2	10	18	1037	65.4	174.	49.
2	11	18	1233	67.9	204.	11.
2	12	18	1418	60.2	212.	12.
3	1	15	2215	24.7	250.	363.
3	2	16	204	27.4	248.	357.
3	3	16	455	34.0	245.	354.
3	4	16	822	32.8	255.	355.
3	5	16	1014	35.8	261.	335.
3	6	16	1334	41.9	259.	321.
3	7	17	1105	57.4	262.	325.
3	8	17	1328	61.2	285.	294.
3	9	17	1548	60.6	289.	295.
3	10	18	1040	65.4	277.	313.
3	11	18	1236	67.8	298.	283.
3	12	18	1441	60.2	301.	283.
4	1	15	2218	24.6	65.	353.
4	2	16	206	27.6	65.	350.
4	3	16	456	34.0	56.	351.
4	4	16	824	32.9	75.	339.
4	5	16	1015	35.8	83.	329.
4	6	16	1335	41.9	89.	304.
4	7	17	1107	57.5	79.	318.
4	8	17	1330	61.3	107.	280.
4	9	17	1551	60.0	123.	281.
4	10	18	1041	65.5	99.	298.
4	11	18	1237	67.8	122.	269.
4	12	18	1422	60.2	127.	270.

PT	RUN	DAY	TIME	TEMP	A	B
5	1	15	2220	24.6	264.	104.
5	2	16	209	27.9	266.	99.
5	3	16	458	34.0	270.	92.
5	4	16	825	33.0	270.	97.
5	5	16	1017	36.0	287.	77.
5	6	16	1338	41.9	283.	68.
5	7	17	1109	57.6	280.	71.
5	8	17	1335	61.4	303.	41.
5	9	17	1554	60.3	310.	43.
5	10	18	1043	65.5	297.	54.
5	11	18	1239	67.8	312.	30.
5	12	18	1423	60.2	318.	28.
6	1	15	2222	24.5	-15.	175.
6	2	16	211	28.0	-16.	176.
6	3	16	459	34.0	-15.	178.
6	4	16	826	33.0	1.	179.
6	5	16	1019	36.1	16.	158.
6	6	16	1340	41.9	18.	147.
6	7	17	1111	57.8	7.	156.
6	8	17	1337	61.5	39.	123.
6	10	18	1045	65.6	31.	133.
6	11	18	1241	67.8	49.	110.
6	12	18	1425	60.2	60.	107.
7	1	15	2236	24.3	132.	276.
7	2	16	214	28.3	135.	274.
7	3	16	506	33.6	123.	275.
7	4	16	828	33.1	133.	268.
7	5	16	1021	36.2	147.	246.
7	6	16	1343	41.9	154.	235.
7	7	17	1113	57.9	148.	241.
7	8	17	1340	61.6	166.	218.
7	9	17	1558	60.1	173.	213.
7	10	18	1046	65.6	158.	227.
7	11	18	1242	67.7	174.	202.
7	12	18	1426	60.2	174.	200.
8	1	15	2240	24.2	46.	298.
8	2	16	217	28.5	47.	293.
8	3	16	509	33.4	42.	295.
8	4	16	831	33.2	55.	291.
8	5	16	1023	36.3	71.	263.
8	6	16	1346	41.9	74.	255.
8	7	17	1119	58.3	74.	253.
8	8	17	1342	61.6	95.	227.
8	9	17	1603	60.0	108.	223.
8	10	18	1053	65.8	82.	238.
8	11	18	1245	67.7	108.	213.
8	12	18	1428	60.2	104.	220.

PT	RUN	DAY	TIME	TEMP	A	B
9	1	15	2242	24.2	311.	384.
9	2	16	219	28.7	313.	379.
9	3	16	511	33.2	317.	373.
9	4	16	833	33.2	325.	370.
9	5	16	1025	36.4	336.	350.
9	6	16	1349	41.9	335.	340.
9	7	17	1225	59.8	344.	333.
9	8	17	1345	61.7	366.	313.
9	9	17	1605	60.0	377.	305.
9	10	18	1058	65.9	355.	316.
9	11	18	1246	67.6	363.	300.
9	12	18	1429	60.2	378.	296.
10	1	15	2246	24.1	10.	82.
10	2	16	222	28.9	8.	73.
10	4	16	836	33.3	18.	68.
10	5	16	1028	36.5	35.	41.
10	6	16	1352	41.9	33.	33.
10	7	17	1129	58.8	36.	28.
10	8	17	1348	61.8	59.	-5.
10	10	18	1103	66.1	48.	9.
10	11	18	1249	67.5	73.	1.
10	12	18	1434	60.2	69.	5.
12	7	17	1137	59.2	35.	92.
12	8	17	1354	61.9	52.	78.
12	10	18	1109	66.2	34.	80.
12	11	18	1254	67.3	55.	67.
12	12	18	1437	60.2	45.	79.
13	1	15	2306	24.0	105.	226.
13	2	16	232	29.6	114.	213.
13	3	16	528	32.2	113.	213.
13	4	16	844	33.6	111.	217.
13	5	16	1038	37.0	136.	184.
13	6	16	1401	42.0	148.	171.
13	7	17	1140	59.3	155.	164.
13	8	17	1357	61.9	169.	149.
13	10	18	1112	66.3	158.	151.
13	11	18	1256	67.2	175.	142.
13	12	18	1438	60.2	166.	147.

PT	RUN	DAY	TIME	TEMP	A	B
14	1	15	2309	23.9	103.	231.
14	2	16	235	29.8	105.	219.
14	3	16	531	32.1	116.	211.
14	4	16	845	33.6	117.	217.
14	5	16	1041	37.2	132.	192.
14	6	16	1404	42.1	144.	178.
14	7	17	1142	59.4	149.	168.
14	8	17	1400	62.0	167.	151.
14	10	18	1113	66.3	155.	153.
14	11	18	1258	67.1	168.	147.
14	12	18	1441	60.2	162.	151.
15	1	15	2313	23.9	135.	232.
15	2	16	237	29.9	136.	226.
15	3	16	533	32.0	137.	223.
15	4	16	848	33.7	138.	228.
15	5	16	1044	37.3	154.	205.
15	6	16	1406	42.2	163.	221.
15	7	17	1145	59.5	170.	176.
15	8	17	1403	62.0	180.	166.
15	10	18	1116	66.4	174.	164.
15	11	18	1301	66.8	192.	148.
15	12	18	1443	60.2	181.	161.
16	1	15	2316	23.9	254.	142.
16	2	16	240	30.1	258.	136.
16	3	16	535	31.9	261.	135.
16	4	16	850	33.7	269.	133.
16	5	16	1046	37.4	281.	106.
16	6	16	1408	42.2	292.	92.
16	7	17	1148	59.6	295.	81.
16	8	17	1405	62.1	304.	74.
16	10	18	1118	66.4	294.	77.
16	11	18	1303	66.5	307.	63.
16	12	18	1444	60.2	302.	73.
17	1	15	2321	23.9	253.	119.
17	2	16	244	30.3	248.	136.
17	3	16	539	31.7	246.	135.
17	4	16	853	33.8	248.	129.
17	5	16	1048	37.5	257.	112.
17	6	16	1411	42.3	268.	110.
17	7	17	1150	59.7	267.	90.
17	8	17	1408	62.1	282.	75.
17	10	18	1119	66.4	263.	88.
17	11	18	1304	66.3	284.	68.
17	12	18	1445	60.2	283.	76.

PT	RUN	DAY	TIME	TEMP	A	B
18	1	15	2346	23.9	228.	392.
18	2	16	247	30.5	224.	387.
18	3	16	542	31.6	220.	392.
18	4	16	855	33.9	227.	384.
18	5	16	1051	37.6	245.	366.
18	6	16	1413	42.4	256.	370.
18	7	17	1152	59.8	261.	338.
18	8	17	1410	62.1	276.	319.
18	10	18	1120	66.4	251.	335.
18	11	18	1306	66.0	282.	316.
18	12	18	1447	60.2	278.	318.
19	1	15	2350	23.9	169.	280.
19	2	16	249	30.6	171.	275.
19	3	16	544	31.5	165.	280.
19	4	16	856	33.9	171.	277.
19	5	16	1053	37.7	185.	249.
19	6	16	1416	42.5	198.	257.
19	7	17	1155	59.9	203.	221.
19	8	17	1413	62.2	206.	221.
19	10	18	1122	66.5	201.	216.
19	11	18	1308	65.7	225.	199.
19	12	18	1449	60.1	215.	211.
20	1	15	2353	23.9	56.	340.
20	2	16	251	30.7	57.	339.
20	3	16	546	31.4	56.	338.
20	4	16	859	34.0	65.	329.
20	5	16	1106	38.2	72.	312.
20	6	16	1419	42.5	87.	320.
20	7	17	1157	59.9	91.	284.
20	8	17	1414	62.2	109.	268.
20	10	18	1124	66.5	97.	269.
20	11	18	1310	65.3	112.	264.
20	12	18	1450	60.1	110.	263.
21	1	15	2356	24.0	31.	229.
21	2	16	254	30.8	41.	210.
21	3	16	548	31.4	35.	212.
21	4	16	901	34.0	40.	211.
21	5	16	1108	38.3	53.	189.
21	6	16	1422	42.6	75.	201.
21	7	17	1200	60.0	82.	156.
21	8	17	1417	62.2	103.	139.
21	10	18	1125	66.5	90.	143.
21	11	18	1311	65.2	104.	142.
21	12	18	1452	60.1	100.	140.

PT	RUN	DAY	TIME	TEMP	A	B
22	1	15	2358	24.0	317.	78.
22	2	16	256	30.9	317.	75.
22	3	16	550	31.3	314.	80.
22	4	16	904	34.0	325.	73.
22	5	16	1111	38.4	331.	51.
22	6	16	1424	42.6	336.	64.
22	7	17	1203	60.0	343.	20.
22	8	17	1419	62.2	365.	11.
22	10	18	1127	66.6	346.	18.
22	11	18	1314	64.7	372.	-5.
22	12	18	1454	60.1	364.	10.
23	1	16	1	24.0	85.	156.
23	2	16	258	30.9	85.	150.
23	3	16	554	31.2	80.	145.
23	4	16	906	34.0	88.	155.
23	5	16	1120	38.7	112.	115.
23	6	16	1428	42.7	121.	145.
23	7	17	1204	59.9	130.	93.
23	8	17	1421	62.2	140.	77.
23	10	18	1130	66.6	130.	91.
23	11	18	1318	64.2	146.	84.
23	12	18	1455	60.1	143.	82.
24	1	16	3	24.0	-27.	354.
24	2	16	305	30.9	-12.	373.
24	3	16	556	31.1	-20.	385.
24	4	16	907	34.0	-21.	381.
24	5	16	1123	38.8	-15.	355.
24	6	16	1429	42.7	10.	374.
24	7	17	1207	59.9	20.	327.
24	8	17	1423	62.2	35.	310.
24	10	18	1131	66.6	22.	316.
24	11	18	1319	64.0	36.	313.
24	12	18	1457	60.0	27.	319.
25	1	16	12	24.1	201.	104.
25	2	16	308	30.8	207.	81.
25	3	16	558	31.1	190.	108.
25	4	16	910	34.0	208.	88.
25	5	16	1125	38.8	225.	86.
25	6	16	1433	42.8	234.	85.
25	7	17	1210	59.9	241.	34.
25	8	17	1426	62.2	267.	11.
25	10	18	1134	66.7	288.	36.
25	11	18	1321	63.8	256.	20.
25	12	18	1459	60.0	251.	21.

PT	RUN	DAY	TIME	TEMP	A	B
26	1	16	15	24.2	255.	39.
26	2	16	313	30.7	255.	38.
26	3	16	600	31.0	255.	31.
26	4	16	911	34.0	251.	32.
26	5	16	1127	38.9	272.	26.
26	6	16	1435	42.8	283.	30.
26	7	17	1211	59.9	290.	-19.
26	8	17	1432	62.2	303.	-36.
26	10	18	1135	66.7	291.	-28.
26	11	18	1323	63.5	304.	-20.
26	12	18	1500	60.0	305.	-40.
27	1	16	17	24.2	175.	258.
27	2	16	314	30.7	181.	248.
27	3	16	601	31.0	175.	243.
27	4	16	913	34.0	184.	239.
27	5	16	1129	39.0	204.	238.
27	6	16	1437	42.9	207.	245.
27	7	17	1214	59.8	217.	191.
27	8	17	1436	62.2	217.	175.
27	10	18	1136	66.7	216.	179.
27	11	18	1324	63.4	232.	170.
28	1	16	21	24.2	156.	280.
28	2	16	316	30.7	153.	271.
28	3	16	603	31.0	145.	263.
28	4	16	914	34.1	160.	258.
28	5	16	1130	39.0	174.	259.
28	6	16	1439	42.9	176.	271.
28	7	17	1217	59.8	185.	212.
28	8	17	1438	62.2	201.	197.
28	10	18	1138	66.7	187.	200.
28	11	18	1325	63.2	199.	193.
29	1	16	23	24.3	127.	292.
29	2	16	318	30.7	121.	278.
29	3	16	605	31.0	128.	270.
29	4	16	916	34.1	134.	262.
29	5	16	1135	39.2	145.	278.
29	6	16	1441	42.9	150.	284.
29	7	17	1219	59.8	156.	222.
29	8	17	1440	62.2	172.	205.
29	10	18	1139	66.8	160.	205.
29	11	18	1327	63.0	175.	199.

PT	RUN	DAY	TIME	TEMP	A	B
30	1	16	25	24.3	115.	389.
30	2	16	320	30.7	123.	375.
30	3	16	607	30.9	117.	385.
30	4	16	918	34.1	127.	373.
30	5	16	1137	39.2	140.	358.
30	6	16	1442	42.9	146.	382.
30	7	17	1221	59.8	153.	328.
30	8	17	1442	62.2	162.	315.
30	10	18	1141	66.8	157.	309.
30	11	18	1328	62.9	168.	307.
31	1	16	27	24.3	144.	369.
31	2	16	322	30.7	151.	354.
31	3	16	609	30.9	166.	351.
31	4	16	919	34.1	161.	351.
31	5	16	1139	39.3	168.	348.
31	6	16	1445	42.9	171.	354.
31	7	17	1223	59.8	179.	301.
31	8	17	1446	62.2	190.	286.
31	10	18	1142	66.8	183.	292.
31	11	18	1330	62.6	201.	285.
32	1	16	36	24.5	28.	358.
32	2	16	339	30.7	38.	382.
32	3	16	622	30.9	46.	381.
32	4	16	922	34.1	44.	360.
32	5	16	1142	39.4	65.	353.
32	6	16	1447	43.0	72.	375.
32	7	17	1225	59.8	82.	321.
32	8	17	1448	62.2	99.	308.
32	10	18	1143	66.8	91.	309.
32	11	18	1331	62.5	103.	305.
33	2	16	350	30.8	329.	89.
33	3	16	628	30.9	339.	90.
33	4	16	926	34.2	347.	74.
33	5	16	1146	39.5	346.	77.
33	6	16	1453	43.0	345.	83.
33	7	17	1230	59.7	368.	31.
33	8	17	1456	62.1	382.	23.
33	10	18	1147	66.9	375.	22.
33	11	18	1335	62.1	390.	17.

PT	RUN	DAY	TIME	TEMP	A	B
34	1	16	43	24.6	320.	46.
34	2	16	352	30.8	315.	36.
34	3	16	630	30.9	326.	40.
34	4	16	927	34.2	333.	39.
34	5	16	1148	39.6	336.	35.
34	6	16	1454	43.0	340.	32.
34	7	17	1231	59.8	349.	-13.
34	8	17	1500	62.0	365.	-25.
34	10	18	1148	66.9	357.	-22.
34	11	18	1336	62.0	373.	-28.
35	2	16	355	30.9	201.	68.
35	3	16	633	30.9	201.	85.
35	4	16	929	34.2	209.	74.
35	5	16	1149	39.6	214.	65.
35	6	16	1457	43.0	228.	75.
35	7	17	1234	59.8	236.	21.
35	8	17	1502	62.0	248.	10.
35	10	18	1150	66.9	237.	15.
35	11	18	1338	61.8	253.	11.
36	1	16	107	25.1	185.	110.
36	2	16	359	31.0	184.	103.
36	3	16	635	30.9	189.	100.
36	4	16	932	34.3	200.	94.
36	5	16	1152	39.7	205.	84.
36	6	16	1500	43.0	214.	85.
36	7	17	1236	59.8	225.	35.
36	8	17	1505	61.9	236.	24.
36	10	18	1153	66.9	228.	19.
36	11	18	1340	61.6	242.	20.
37	1	16	112	25.2	3.	377.
37	2	16	402	31.2	6.	372.
37	3	16	639	30.9	3.	383.
37	4	16	934	34.3	9.	367.
37	5	16	1154	39.8	21.	347.
37	6	16	1502	43.0	31.	357.
37	7	17	1238	59.8	43.	317.
37	8	17	1507	61.9	55.	307.
37	10	18	1156	67.0	48.	312.
37	11	18	1342	61.4	57.	311.

PT	RUN	DAY	TIME	TEMP	A	B
38	1	16	114	25.3	108.	267.
38	2	16	404	31.4	108.	265.
38	3	16	641	30.9	115.	266.
38	4	16	937	34.4	124.	259.
38	5	16	1157	39.9	128.	240.
38	6	16	1505	43.0	132.	235.
38	7	17	1240	59.8	143.	211.
38	8	17	1511	61.8	159.	200.
38	10	18	1158	67.0	148.	200.
38	11	18	1343	61.3	166.	199.
39	1	16	116	25.3	229.	237.
39	2	16	408	31.7	233.	227.
39	3	16	643	30.9	243.	226.
39	4	16	939	34.4	246.	227.
39	5	16	1158	39.9	250.	206.
39	6	16	1508	43.0	254.	201.
39	7	17	1243	59.8	269.	171.
39	8	17	1514	61.7	279.	161.
39	10	18	1201	67.1	271.	163.
39	11	18	1346	61.0	286.	157.
40	1	16	119	25.4	149.	54.
40	2	16	411	32.0	155.	43.
40	3	16	645	30.9	158.	38.
40	4	16	940	34.4	158.	42.
40	5	16	1200	40.0	162.	30.
40	6	16	1510	43.0	169.	13.
40	7	17	1248	59.8	186.	-12.
40	8	17	1516	61.7	192.	-16.
40	10	18	1202	67.1	187.	-18.
40	11	18	1347	60.9	201.	-20.
41	1	16	121	25.5	176.	192.
41	2	16	412	32.1	182.	181.
41	3	16	647	30.9	181.	193.
41	4	16	942	34.5	194.	175.
41	5	16	1201	40.0	203.	164.
41	6	16	1512	43.0	204.	160.
41	7	17	1248	59.8	223.	127.
41	8	17	1518	61.6	237.	117.
41	10	18	1204	67.2	233.	112.
41	11	18	1349	60.8	239.	113.

PT	RUN	DAY	TIME	TEMP	A	B
42	1	16	123	25.5	147.	79.
42	2	16	414	32.2	147.	71.
42	3	16	649	30.9	145.	80.
42	4	16	944	34.5	154.	72.
42	5	16	1203	40.1	162.	50.
42	6	16	1515	42.9	170.	42.
42	7	17	1249	59.9	183.	14.
42	8	17	1522	61.5	190.	13.
42	10	18	1205	67.3	188.	16.
42	11	18	1351	60.6	195.	17.
43	1	16	39	24.5	220.	168.
43	2	16	347	30.7	227.	171.
43	3	16	624	30.9	223.	174.
43	4	16	924	34.2	241.	163.
43	5	16	1144	39.5	253.	164.
43	6	16	1450	43.0	258.	160.
43	7	17	1228	59.8	259.	108.
43	8	17	1453	62.1	285.	103.
43	10	18	1146	66.9	277.	103.
43	11	18	1333	62.3	293.	98.

APPENDIX C

DATA RECORDED WITH VEHICLE MOVING BETWEEN CHECKPOINTS 34 AND 35

A CHANNEL PHASE ZERO	B CHANNEL PHASE ZERO	A CHANNEL PHASE ZERO	B CHANNEL PHASE ZERO	A CHANNEL PHASE ZERO	B CHANNEL PHASE ZERO	A CHANNEL PHASE ZERO	B CHANNEL PHASE ZERO	A CHANNEL PHASE ZERO	B CHANNEL PHASE ZERO
15 6051	337 5106	14 6051	332 5106	13 6051	336 5106	11 6051	333 5106	8 6051	336 5106
8 6051	334 5106	12 6051	335 5106	12 6051	333 5106	11 6051	334 5106	11 6051	334 5106
11 6051	334 5106	7 6051	335 5106	10 6051	334 5106	13 6051	336 5106	12 6051	334 5106
10 6051	335 5106	9 6051	339 5106	9 6051	337 5106	9 6051	336 5106	11 6051	337 5106
12 6051	333 5106	10 6051	336 5106	9 6051	337 5106	7 6051	334 5106	9 6051	336 5106
12 6051	335 5106	12 6051	334 5106	10 6051	334 5106	12 6051	335 5106	8 6051	334 5106
10 6051	336 5106	11 6051	336 5106	11 6051	336 5106	14 6051	332 5106	9 6051	335 5106
9 6051	336 5106	7 6051	338 5106	7 6051	338 5106	10 6051	338 5106	14 6051	334 5106
13 6051	333 5106	9 6051	334 5106	9 6051	338 5106	9 6051	334 5106	10 6051	336 5106
12 6051	336 5106	13 6051	331 5106	10 6051	337 5106	9 6051	334 5106	7 6051	336 5106
7 6051	336 5106	9 6051	335 5106	11 6051	335 5106	12 6051	335 5106	11 6051	337 5106
10 6051	338 5106	9 6051	336 5106	10 6051	335 5106	10 6051	338 5106	11 6051	336 5106
12 6051	335 5106	9 6051	338 5106	9 6051	338 5106	11 6051	342 5106	15 6051	355 5106
16 6051	346 5106	18 6051	350 5106	19 6051	321 5106	22 6051	340 5106	26 6051	8 5107
32 6051	13 5107	37 6051	22 5107	37 6051	31 5107	44 6051	40 5107	49 6051	46 5107
54 6051	59 5107	62 6051	67 5107	65 6051	76 5107	71 6051	85 5107	75 6051	95 5107
83 6051	107 5107	89 6051	118 5107	89 6051	129 5107	94 6051	144 5107	95 6051	158 5107
99 6051	170 5107	102 6051	186 5107	101 6051	200 5107	103 6051	214 5107	102 6051	225 5107
103 6051	239 5107	104 6051	254 5107	107 6051	265 5107	105 6051	277 5107	104 6051	292 5107
107 6051	307 5107	110 6051	320 5107	113 6051	340 5107	113 6051	354 5107	112 6051	12 5108
112 6051	23 5108	114 6051	39 5108	117 6051	52 5108	118 6051	66 5108	116 6051	83 5108
116 6051	99 5108	115 6051	120 5108	114 6051	137 5108	114 6051	156 5108	100 6051	180 5108
105 6051	198 5108	103 6051	223 5108	104 6051	240 5108	102 6051	263 5108	100 6051	284 5108
95 6051	306 5108	98 6051	330 5108	100 6051	350 5108	98 6051	3 5109	97 6051	39 5109
97 6051	58 5109	98 6051	85 5109	96 6051	105 5109	97 6051	128 5109	91 6051	161 5109
89 6051	181 5109	87 6051	213 5109	84 6051	238 5109	84 6051	266 5109	81 6051	290 5109
78 6051	317 5109	75 6051	356 5109	75 6051	5110	75 6051	40 5110	71 6051	75 5110
71 6051	94 5110	70 6051	127 5110	68 6051	161 5110	67 6051	194 5110	59 6051	233 5110
54 6051	264 5110	52 6051	294 5110	50 6051	324 5110	50 6051	355 5110	46 6051	27 5111
44 6051	55 5111	42 6051	85 5111	41 6051	120 5111	40 6051	143 5111	36 6051	181 5111
31 6051	211 5111	29 6051	251 5111	27 6051	285 5111	23 6051	315 5111	19 6051	335 5111
14 6051	21 5112	13 6051	51 5112	14 6051	90 5112	9 6051	119 5112	5 6051	151 5112
4 6051	182 5112	5 6051	216 5112	1 6051	249 5112	357 6050	285 5112	353 6050	321 5112
349 6050	312 5112	348 6050	24 5113	346 6050	58 5113	338 6050	86 5113	339 6050	120 5113
342 6050	150 5113	340 6050	174 5113	339 6050	208 5113	337 6050	235 5113	331 6050	271 5113
330 6050	301 5113	323 6050	331 5113	318 6050	4 5114	314 6050	32 5114	311 6050	56 5114
315 6050	78 5114	314 6050	101 5114	311 6050	125 5114	306 6050	159 5114	305 6050	179 5114
303 6050	208 5114	300 6050	231 5114	297 6050	255 5114	294 6050	280 5114	285 6050	306 5114
292 6050	335 5114	287 6050	340 5114	283 6050	25 5115	282 6050	47 5115	280 6050	68 5115
284 6050	83 5115	284 6050	102 5115	280 6050	120 5115	279 6050	142 5115	275 6050	163 5115
275 6050	187 5115	270 6050	207 5115	269 6050	232 5115	267 6050	255 5115	264 6050	275 5115
265 6050	299 5115	264 6050	328 5115	265 6050	343 5115	260 6050	18 5116	254 6050	43 5116
255 6050	64 5116	254 6050	82 5116	255 6050	100 5116	251 6050	125 5116	246 6050	147 5116
247 6050	171 5116	246 6050	199 5116	234 6050	225 5116	239 6050	254 5116	232 6050	280 5116
230 6050	305 5116	232 6050	330 5116	234 6050	346 5116	229 6050	27 5117	227 6050	54 5117
225 6050	77 5117	225 6050	107 5117	222 6050	128 5117	218 6050	153 5117	210 6050	177 5117
209 6050	209 5117	207 6050	234 5117	212 6050	265 5117	206 6050	293 5117	203 6050	323 5117
203 6050	345 5117	203 6050	25 5118	203 6050	40 5118	195 6050	71 5118	192 6050	101 5118
190 6050	125 5118	187 6050	156 5118	181 6050	182 5118	181 6050	210 5118	175 6050	237 5118
175 6050	271 5118	176 6050	301 5118	171 6050	330 5118	169 6050	319 5118	169 6050	16 5120
170 6050	55 5120	166 6050	86 5120	160 6050	116 5120	159 6050	146 5120	156 6050	179 5120
154 6050	203 5120	148 6050	234 5120	143 6050	261 5120	138 6050	292 5120	139 6050	325 5120
139 6050	345 5120	135 6050	28 5121	132 6050	58 5121	134 6050	87 5121	136 6050	120 5121
127 6050	150 5121	122 6050	184 5121	118 6050	216 5121	114 6050	245 5121	113 6050	273 5121

A CHANNEL		B CHANNEL		A CHANNEL		B CHANNEL		A CHANNEL		B CHANNEL		A CHANNEL		B CHANNEL		A CHANNEL		B CHANNEL	
PHASE	ZERO	PHASE	ZERO	PHASE	ZERO	PHASE	ZERO	PHASE	ZERO	PHASE	ZERO	PHASE	ZERO	PHASE	ZERO	PHASE	ZERO	PHASE	ZERO
108	6050	303	5121	102	6050	335	5121	101	6050	356	5121	100	6050	41	5122	101	6050	69	5122
97	6050	104	5122	96	6050	134	5122	95	6050	169	5122	90	6050	202	5122	85	6050	237	5122
79	6050	267	5122	75	6050	295	5122	76	6050	326	5122	72	6050	341	5122	70	6050	36	5123
67	6050	66	5123	65	6050	94	5123	66	6050	124	5123	67	6050	157	5123	60	6050	192	5123
55	6050	230	5123	51	6050	264	5123	52	6050	299	5123	47	6050	329	5123	41	6050	6	5124
38	6050	69	5123	34	6050	74	5123	36	6050	100	5123	34	6050	135	5123	30	6050	166	5123
28	6050	200	5123	24	6050	233	5123	21	6050	274	5123	17	6050	306	5123	13	6050	342	5123
11	6050	32	5124	14	6050	52	5124	12	6050	97	5124	13	6050	120	5124	6	6050	155	5124
7	6050	192	5124	2	6050	226	5124	355	6049	266	5124	349	6049	304	5124	348	6049	339	5124
349	6049	350	5124	344	6049	46	5125	344	6049	89	5125	344	6049	115	5125	344	6049	156	5125
342	6049	190	5125	338	6049	228	5125	335	6049	268	5125	334	6049	308	5125	332	6049	342	5125
326	6049	22	5126	324	6049	51	5126	327	6049	90	5126	327	6049	127	5126	323	6049	164	5126
318	6049	200	5126	319	6049	236	5126	322	6049	276	5126	314	6049	319	5126	311	6049	324	5126
309	6049	36	5127	311	6049	71	5127	310	6049	106	5127	309	6049	145	5127	304	6049	182	5127
305	6049	221	5127	303	6049	253	5127	299	6049	296	5127	296	6049	333	5127	293	6049	18	5128
292	6049	54	5128	289	6049	91	5128	286	6049	127	5128	281	6049	168	5128	287	6049	203	5128
285	6049	243	5128	282	6049	273	5128	277	6049	311	5128	283	6049	348	5128	278	6049	31	5129
275	6049	59	5129	275	6049	95	5129	274	6049	124	5129	272	6049	157	5129	271	6049	192	5129
267	6049	223	5129	269	6049	251	5129	267	6049	279	5129	272	6049	307	5129	270	6049	351	5129
267	6049	349	5129	268	6049	36	5130	264	6049	63	5130	265	6049	84	5130	265	6049	109	5130
263	6049	130	5130	263	6049	156	5130	263	6049	182	5130	262	6049	209	5130	260	6049	232	5130
257	6049	253	5130	257	6049	271	5130	256	6049	294	5130	259	6049	318	5130	256	6049	336	5130
158	6049	351	5130	254	6048	20	5131	253	6048	42	5131	256	6048	57	5131	253	6048	76	5131
254	6048	90	5131	253	6048	106	5131	256	6048	121	5131	255	6048	134	5131	255	6048	146	5131
252	6048	162	5131	251	6048	178	5131	250	6048	189	5131	257	6048	204	5131	251	6048	218	5131
252	6048	231	5131	248	6048	246	5131	248	6048	256	5131	249	6048	264	5131	252	6048	276	5131
253	6048	284	5131	252	6048	295	5131	250	6048	307	5131	250	6048	317	5131	252	6048	328	5131
252	6048	335	5131	251	6048	346	5131	249	6048	342	5131	249	6048	326	5131	250	6048	7	5132
249	6048	22	5132	252	6048	24	5132	251	6048	21	5132	250	6048	27	5132	251	6048	30	5132
251	6048	30	5132	250	6048	31	5132	252	6048	28	5132	251	6048	34	5132	253	6048	29	5132
252	6048	28	5132	250	6048	26	5132	249	6048	24	5132	249	6048	28	5132	252	6048	23	5132
252	6048	27	5132	250	6048	25	5132	250	6048	29	5132	246	6048	26	5132	250	6048	25	5132
253	6048	26	5132	255	6048	27	5132	253	6048	27	5132	251	6048	28	5132	251	6048	26	5132
250	6048	24	5132	250	6048	14	5132	252	6048	27	5132	255	6048	25	5132	252	6048	28	5132
251	6048	27	5132	250	6048	26	5132	250	6048	27	5132	251	6048	27	5132	253	6048	27	5132
254	6048	24	5132	253	6048	27	5132	250	6048	27	5132	251	6048	26	5132	249	6048	23	5132
249	6048	23	5132	252	6048	28	5132	251	6048	28	5132	255	6048	27	5132	250	6048	30	5132
249	6048	24	5132	252	6048	26	5132	252	6048	23	5132	253	6048	27	5132	253	6048	27	5132
252	6048	30	5132	251	6048	30	5132	249	6048	23	5132	251	6048	24	5132	254	6048	21	5132
251	6048	26	5132	253	6048	28	5132	254	6048	24	5132	247	6048	24	5132	249	6048	24	5132
252	6048	25	5132	254	6048	25	5132	254	6048	22	5132	254	6048	23	5132	251	6048	23	5132
250	6048	22	5132	253	6048	19	5132	251	6048	20	5132	255	6048	19	5132	252	6048	23	5132
252	6048	19	5132	250	6048	20	5132	250	6048	19	5132	250	6048	17	5132	250	6048	16	5132
253	6048	20	5132	253	6048	18	5132	252	6048	18	5132	251	6048	15	5132	249	6048	20	5132
251	6048	15	5132	250	6048	21	5132	253	6048	18	5132	253	6048	18	5132	250	6048	19	5132
251	6048	16	5132	248	6048	27	5132	250	6048	16	5132	251	6048	16	5132	251	6048	20	5132
252	6048	17	5132	251	6048	19	5132	248	6048	16	5132	251	6048	17	5132	254	6048	6	5132
255	6048	6	5132	253	6048	18	5132	251	6048	17	5132	249	6048	14	5132	250	6048	4	5132
249	6048	15	5132	252	6048	17	5132	253	6048	17	5132	252	6048	16	5132	251	6048	17	5132
248	6048	18	5132	250	6048	18	5132	250	6048	19	5132	252	6048	15	5132	254	6048	20	5132
254	6048	17	5132	252	6048	15	5132	250	6048	18	5132	251	6048	14	5132	250	6048	20	5132
254	6048	4	5132	251	6048	18	5132	253	6048	17	5132	250	6048	17	5132	249	6048	19	5132
249	6048	17	5132	253	6048	18	5132	253	6048	18	5132	252	6048	18	5132	251	6048	19	5132
249	6048	15	5132	250	6048	7	5132	250	6048	3	5132	251	6048	19	5132	253	6048	6	5132
252	6048	18	5132	252	6048	19	5132	250	6048	18	5132	249	6048	19	5132	252	6048	4	5132